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Article

Socioeconomic inequality in morbid obesity with body mass index more than 40 kg/m² in the United States and England



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ABSTRACT

Introduction: This study evaluated socioeconomic inequality in morbid obesity (body mass index, BMI ≥ 40 kg/m²) through an analysis of population health survey data in the United States (US) and England (UK).

Methods: We analysed data for the National Health and Nutrition Examination Survey and the Health Survey for England for 2011 to 2014. Age-adjusted odds ratios (AOR) were used to evaluate income- and education-inequality.

Results: There were 26,898 eligible UK and 10,628 US participants. Morbid obesity was more frequent in women than men, and higher in the US than the UK (men: US, 4.8%; UK, 1.7%; women US, 9.6%; UK, 3.7%). In the UK, morbid obesity showed graded income-inequality in both genders (AOR, for lowest income quintile: men, 1.83, 95% confidence interval 1.16 to 2.88; women, 2.18, 1.55 to 3.07), as well as education-inequality (AOR for no school qualifications, men 2.57, 1.64 to 4.02; women, 2.18, 1.55 to 3.07). In the US, morbid obesity showed a consistent gradient only for income in women (AOR for lowest income quintile 1.97, 1.19 to 3.25). When compared with all other US groups, having college education (AOR, men, 0.56, 0.29 to 1.08; women, 0.36, 0.22 to 0.60) or household income $\geq \$75,000$ (AOR, men 0.52, 0.27 to 0.98; women, 0.51, 0.33 to 0.80) appeared to protect against morbid obesity.

Conclusions: Morbid obesity is associated with lower socioeconomic status in men and women in the UK. In the US, morbid obesity was twice as prevalent, but less strongly associated with socioeconomic status, suggesting that morbid obesity may now have spread to all but the highest socioeconomic groups.

1. Introduction

1.1. Background

Obesity is a major global health problem (NCD Risk Factor Collaboration, 2016a) with important implications for population health (NCD Risk Factor Collaboration, 2016b). People with morbid obesity (body mass index, BMI ≥ 40 kg/m²) are disproportionately affected by the health consequences of obesity, often experiencing the premature onset of multiple morbidities (Booth et al., 2014b). Diabetes is particularly important, developing in up to 3% per year (Booth, PrevostGulliford, 2014a).

Morbid obesity affects 0.64% of men and 1.6% of women worldwide (NCD Risk Factor Collaboration, 2016a) but the prevalence of morbid obesity is considerably greater in high income countries, where the rate of increase has been very rapid. In England, 0.2% of men and 1.4% of women had morbid obesity in 1993, but by 2014 morbid obesity

affected 1.8% of men and 3.6% of women (Joint Health Surveys Unit, 2014). In the United States, morbid obesity increased from 3.9% of the population in 2000 to 6.6% in 2010 (Sturm & Hattori, 2013).

1.2. Socioeconomic status and obesity

The rise in obesity appears to result from changes in the social environment that facilitate the development of obesity in susceptible individuals. Social environmental exposures may be differentially distributed across socioeconomic groups with men and women showing differing patterns of association. Previous studies demonstrate an important gender distinction in the association of socioeconomic status with simple obesity (BMI ≥ 30 Kg/m²). In their seminal review, Sobal and Stunkard, (1989) showed that in high-income countries obesity was associated with lower socioeconomic position in women, but this pattern of association was not generally observed in men. This is in contrast to the situation in low- and middle-income countries where

Abbreviations: (NHANES), National Health and Nutrition Survey; (HSE), Health Survey for England; (CSE), certificate of secondary education; (AOR), age-adjusted odds ratio; NCD, Non-communicable disease

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obesity may be associated with affluence. Recent empirical studies have confirmed the observation of Sobal and Stunkard, that a socioeconomic gradient in obesity is generally only observed in women in high-income countries. (Devaux & Sassi, 2013; García Villar & Quintana-Domeque, 2009; Sassi, Devaux, Cecchini & Rusticella, 2009) McLaren (2007) analysed 1914 estimates from 333 published studies. In women from high income countries, obesity was negatively associated with occupational level for 100/146 (68%) of estimates. In men, obesity showed either no association or non-linear associations with education (35/50, 70% of estimates) or employment level (28/33, 85% of estimates) (McLaren, 2007).

The causal mechanisms underlying the association of obesity with lower socioeconomic status may be complex and possibly bidirectional (Department of Health Public Health Research Consortium et al., 2007; Finkelstein, Ruhm & Kosa, 2005). Lower availability and affordability of healthy foods (Drewnowski, 2009) and lower participation in physical activity (Beenackers et al., 2012) may be important factors in lower socioeconomic groups. Increased susceptibility to poverty, and to the effects of poverty, in women may play a role in gender differences. Reverse causation may also contribute to gender inequalities; an example of which is increased discrimination against overweight and obesity in the workplace, a phenomenon that appears to impact more heavily on women than men (García Villar & Quintana-Domeque, 2009).

1.3. Hypotheses and rationale for the study

Cross-country comparisons may offer important insights into the origins and determinants of population health and inequalities in health (Mackenbach et al., 2008). There may be substantial differences in health outcomes, and inequalities in health measures, even among countries with broadly similar aggregate levels of economic achievement (Wilkinson, 1997). Devaux and Sassi (2013) compared the prevalence of obesity in 11 OECD countries, showing that socioeconomic inequalities in obesity were greater than for overweight, and greater in women than men. In a recent study, which contrasted the U.S. and Canada, Siddiqi, Brown, Nguyen, Loopstra, and Kawachi (2015) suggested that the association of educational-level with all obesity may vary across countries. In Canada, having less than high school education was associated with obesity, while in the US all groups except for the college-educated were obese. Previous studies have not evaluated the social patterning of morbid obesity. Morbid obesity is a particular concern to public health because it is associated with disproportionately large health impacts and costs (Arterburn, Maciejewski & Tsevat, 2005; Rudisill, Charlton, Booth & Gulliford, 2016).

The United States (US) and England (UK) have among the highest rates of obesity, and morbid obesity, in the world. The two countries share cultural similarities and a 'liberal' economic system (Bambra, 2007; Hall & Soskice, 2001); the US is more affluent overall but access to services and social protection may often be more favourable in the UK. Analysing data from these two OECD countries offers an opportunity to compare the social patterning of overweight and obesity at different levels of overall prevalence. This analysis is timely in the context of the continued global rise of morbid obesity.

This study aimed to evaluate income- and education-related inequalities in morbid obesity through a comparison of national population health surveys from the UK and the US. We hypothesised that socioeconomic inequalities in morbid obesity may be more consistent than for all obesity ($\text{BMI} \geq 30 \text{ kg/m}^2$), based on the observation that inequalities in obesity are greater than for overweight (Devaux & Sassi, 2013). If obese people are more likely to have a low socioeconomic position, it might be expected that those who attain extreme levels of obesity have an even greater likelihood of occupying a lower position in the socioeconomic gradient. We also hypothesised that inequalities in morbid obesity might be present in men as well as

women.

2. Methods

2.1. Data source and collection

Data from the US National Health and Nutrition Examination Survey (NHANES) for 2011–12 and 2013–14 were analysed. The NHANES employs a multistage design aimed at selecting participants who are representative of the civilian United States (US) population (Centers for Disease Control, 2016). In NHANES, the response rate ranged from 45% in participants aged over 80 years to 71% in ages 30 to 39 (National Center for Health Statistics, 2015). Data from the Health Survey for England (HSE) were analysed for 2011 to 2014. The HSE also employs a multistage cluster sampling design to draw a representative sample of the non-institutional population in England (Mindell et al., 2012). Annual response rates for measurements ranged from 56% to 62% (Mindell et al., 2012). Participants who were under the age of 20 at the time of the survey were excluded from these analyses, as were those who did not have a valid BMI measurement or were pregnant during the time of the survey. Multiple years were selected to give a larger sample size. Response rates were similar for the two surveys, consistent with reducing participation rates observed in national surveys (Mindell et al., 2015).

2.2. Exposures, outcomes and co-variables

Height and weight records were obtained by the interviewer through standardised measurements (Mindell et al., 2012; Centers for Disease Control and Prevention, 2016) and used to calculate BMI. Morbid obesity was defined as a BMI of $\geq 40 \text{ kg/m}^2$.

Questionnaire data for highest educational qualification and household income were used to evaluate socioeconomic position. In NHANES, participants were asked 'what is the highest grade or level of school you have completed or the highest degree received'. Responses were grouped into the categories 'less than 9th grade', '9th to 11th grade' at ages 14 to 17, 'high school graduate' typically at age 18, 'some college or associate degree', 'college graduate or above', 'refused' and 'not known or missing'. In the HSE, the highest educational qualification was coded into the categories: university or college degree; higher education; A-level school examinations taken at 18 years; O-level or GCSE school examinations taken at 16 years; certificate of secondary education (CSE) taken at 14–16 years at a lower level than GCSE; no qualifications; and not disclosed. The resulting education categories were judged to be broadly comparable when mapped using the International Standard Classification of Education (ISCED) (UNESCO Institute of Statistics, 2012).

Total household income was consistently recorded between the two surveys and was used for the analysis. Household income data were collected using pre-defined categories. In NHANES, annual household income was grouped into the categories: $\geq \$75\,000$, $\$55\,000$ to $\$74\,999$, $\$35\,000$ to $\$54\,999$, $\$20\,000$ to $\$34\,999$, $< \$20\,000$ and not disclosed. In HSE, total household income was divided into the categories $\geq £52\,000$, $£33\,800$ to $£52\,000$, $£23\,400$ to $£33\,800$, $£13\,000$ to $£23\,400$, $< £13\,000$ and not disclosed.

Self-reported ethnicity from the HSE was analysed using the categories: 'white', 'black' (including black African, black Caribbean and black other), 'Asian', 'mixed', 'other' and 'not disclosed'. Items concerning race and ethnicity from NHANES were mapped to the same categories with the additional categories of 'Mexican American' and 'Other Hispanic'.

2.3. Analysis

Analyses were conducted separately in men and women so as to test our second hypothesis relating to gender differences. The 'survey'

commands in the Stata and R programs were employed to account for the sampling design, based on the primary sampling units from the Health Survey for England and the sampling weights from NHANES (R Core Team, 2016; Stata Corp, 2015). Prevalence rates for morbid obesity were calculated by age group, ethnicity, income and education. Prevalence rates were age-standardised using the direct method based on 2000 US census data. The US has a younger population structure than the UK, but we chose to use one reference population to allow comparison. UK rates standardised to the European Standard Population are presented in a [Supplementary file](#).

Logistic regression models were used to estimate the relative odds of morbid obesity by category of income or education, adjusting for age. Age-adjusted logistic regression models were also used to compare rates of morbid obesity in the highest socioeconomic category with the remaining participants. Sensitivity analyses were performed to assess the effect of adjusting for ethnicity because some ethnic groups are known to have higher obesity rates. The analyses were repeated using equivalised income, which adjusted for household size, to test the robustness of household income as a measure of socioeconomic status. These results are presented in the [Supplementary file](#).

3. Results

From 2011 to 2014, there were 32,225 adults aged 20 years and older who participated in the HSE of whom 26,898 (83%) provided valid BMI measurements. There were 11,317 participants in NHANES 2011 from 2014, of whom 10,628 (94%) had valid BMI values.

The distribution of the sample by age and ethnicity and the

prevalence of morbid obesity are presented in [Table 1](#). The overall prevalence of morbid obesity in men was 1.7% in the UK and 4.8% in the US. For women the figures were 3.7% and 9.6% respectively. Morbid obesity was high in 'black' women but less so in men, with 16.0% of non-Hispanic black women in the US and 5.4% of 'black' women in the UK having morbid obesity.

The age-standardised prevalence of morbid obesity according to income and education category is presented for English and US participants in [Fig. 1](#) and [Tables 2 and 3](#) for men and women respectively. [Fig. 1](#) reveals consistent gradients in the distribution of morbid obesity according to income and education in both men and women in England. In English men, the prevalence of morbid obesity was 1.3% in the highest category of income and 2.3% in the lowest; in English women, the equivalent figures were 2.0% and 5.0%. English men in the highest category of educational qualification had a prevalence of morbid obesity of 0.9% compared with 2.4% in the lowest category; in women, the equivalent figures were 2.2% and 4.9%.

In the US, there was a gradient in the distribution of morbid obesity by income in women: 5.8% of the highest income category had morbid obesity compared with 12.0% in the lowest income category. In US men, there was no consistent gradient. US men in the highest income category had a prevalence of morbid obesity of 3.7%. The remaining income categories all showed values between 5% and 6%, except the lowest category at 6.2%. In the US, the highest category of education showed the lowest prevalence of morbid obesity (2.9% in men and 5.3% in women), but the second highest education category showed the highest prevalence of morbid obesity (6.2% in men and 11.8% in women).

Table 1

Prevalence of morbid obesity in men and women from England and United States. Figures are frequencies except where indicated.

		England		United States	
		n/N	Prevalence (%)	n/N	Prevalence (%)
MEN					
Total		209/12,161	1.72	249/5219	4.84
Age group	20 to 34	32/2422	1.32	68/1421	4.79
	35 to 44	44/2179	2.02	53/879	6.03
	45 to 54	50/2293	2.18	40/861	4.65
	55 to 64	52/2097	2.48	55/919	5.98
	65 to 74	23/1943	1.18	25/646	3.87
	75 and over	8/1227	0.65	8/493	1.62
Ethnic group	White	195/10,932	1.80	101/2091	5.13
	Mexican	–	–	31/627	5.10
	Other Hispanic	–	–	16/460	3.58
	Mixed race	4/128	4.79	–	–
	Asian	8/753	0.95	2/665	0.25
	Black	0/257	–	86/1215	7.10
	Other	2/81	2.04	13/161	7.38
	Not disclosed	0/10	–	–	–
WOMEN					
Total		555/14,737	3.77	514/5409	9.57
Age group	20 to 34	108/3155	3.42	124/1302	9.52
	35 to 44	112/2727	4.11	95/979	9.70
	45 to 54	127/2855	4.45	114/966	11.80
	55 to 64	100/2412	4.15	112/940	11.91
	65 to 74	75/2113	3.55	51/697	7.32
	75 and over	33/1475	2.24	18/525	3.43
Ethnic group	White	500/13,142	3.82	194/2150	9.63
	Mexican	–	–	59/609	9.06
	Other Hispanic	–	–	36/554	6.19
	Mixed race	6/175	3.23	–	–
	Asian	22/899	2.59	6/691	0.90
	Black	25/392	5.79	200/1258	16.0
	Other	1/112	0.77	19/147	13.6
	Not disclosed	1/17	11.8	–	–

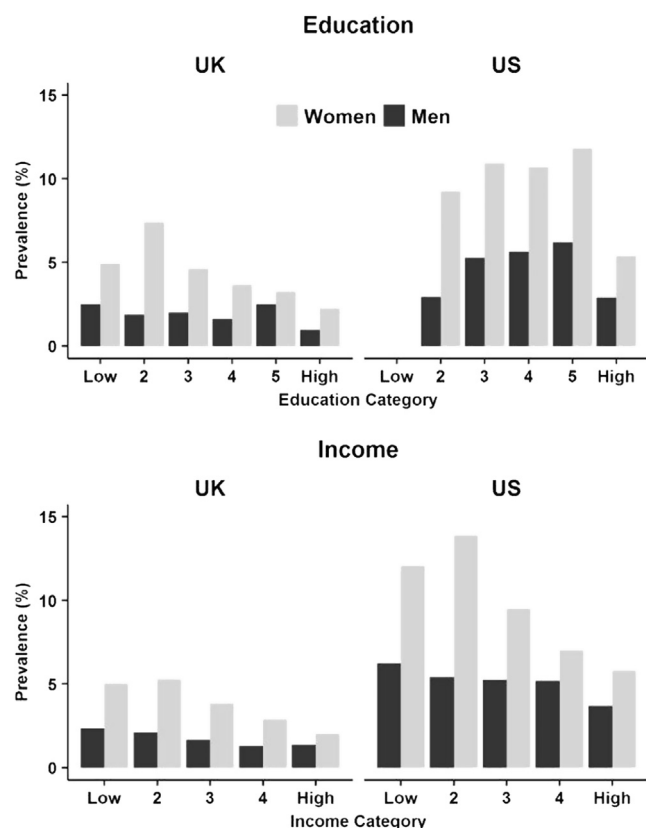


Fig. 1. Age-standardised prevalence of morbid obesity by household income (upper panel) and education (lower panel) in England and the USA. Black bars, men; gray bars, women.

Age-adjusted odds ratios (AOR) of morbid obesity by income and by education are presented in Tables 2 and 3. These estimates confirm a graded association of morbid obesity with income and education category in both English men and women. In the lowest category of income, compared with the highest, the relative odds of morbid obesity were 1.83 (95% confidence interval 1.16 to 2.88) in men and 2.92 (2.07 to 4.12) in women. In the lowest category of education, compared with the highest, the relative odds of morbid obesity were 2.57 (1.64 to 4.02) in men and 2.61 (1.95 to 3.48) in women. In US women, there was evidence of a gradient in morbid obesity related to income, with

relative odds for the lowest income category of 1.97 (1.19 to 3.25). In US men, the greatest odds of morbid obesity were for the second highest category of income (AOR 2.65, 1.08 to 6.53). In both US men and women, the greatest odds of morbid obesity were for the second highest category of education (some college education or associate degree, men 2.31, 1.13 to 4.69; women, 3.11, 1.83 to 5.28).

Inspection of estimates in Fig. 1 suggested that, in the US, people with highest level of education or income might have some protection against morbid obesity, when compared with all other groups. Table 4 presents a comparison of the prevalence of morbid obesity in those from the highest income (greater than £52 000 or \$75 000) or education (degree or college) categories in both settings, compared with all others. The likelihood of morbid obesity for US men in the highest category of income was approximately half that of the remainder of the population (AOR 0.53, 0.27 to 0.98). A similar pattern was observed for US women, for both the highest category of income (AOR 0.51, 0.33 to .80 and the highest category of education (AOR 0.36, 0.22 to 0.60). This finding was not statistically significant for education as a predictor in US men (AOR 0.56, 0.29 to 1.08). UK men were less likely to be morbidly obese if they were in the highest education category (AOR 0.46, 0.31 to 0.66), but not if they were in the highest income category (AOR 0.73, 0.50 to 1.06). In the UK data, the association was stronger in women than men (AOR for income 0.42, 0.31 to 0.57; AOR for education 0.48, 0.37 to 0.61). Adjusting for ethnicity did not alter the results.

4. Discussion

4.1. Summary of findings

The present results provide new evidence of socioeconomic inequality in morbid obesity in two high-income countries with differing obesity profiles. While the results affirm that socioeconomic disparities are generally greater among women, the findings support the hypothesis that inequalities in morbid obesity are evident in men as well as women.

The study provided evidence of consistent socioeconomic gradients in morbid obesity according to income and education in England, where morbid obesity is less frequent overall. The lowest rates of morbid obesity in any US socioeconomic group were greater than the highest rates in England, suggesting that social environmental exposures, characterised as the ‘obesogenic environment’, may be more pervasive across social strata in the U.S. (Banks, Marmot, Oldfield & Smith, 2006; Siddiqi et al., 2015). In the US, socioeconomic gradients

Table 2

Age-standardised prevalence and logistic regression model of morbid obesity in men from England and the USA by income and education category. Figures are frequencies except where indicated.

	England				United States		
	n/N	Prevalence (%)	AOR ^a (95% CI)		n/N	Prevalence (%)	AOR ^a (95% CI)
Household income				Household income			
Highest (≥£52,000)	37/2446	1.35	1.00	Highest (≥\$75,000)	48/1284	3.69	1.00
£33,800 to £52,000	24/1784	1.28	0.93 (0.55 to 1.55)	\$55,000 to \$74,999	28/504	5.18	2.65 (1.08, 6.53)
£23,400 to £33,800	29/1758	1.64	1.22 (0.75 to 1.98)	\$35,000 to \$54,999	43/834	5.24	1.93 (0.83, 4.49)
£13,000 to £23,400	42/2167	2.11	1.62 (1.03 to 2.54)	\$20,000 to \$34,999	53/988	5.39	2.17 (0.97, 4.88)
Lowest (<£13,000)	36/1618	2.35	1.83 (1.16 to 2.88)	Lowest (<\$20,000)	65/1232	6.22	1.50 (0.75, 3.01)
Not disclosed	41/2388	1.74	1.37 (0.88 to 2.13)	Not disclosed	12/377	3.31	0.65 (0.22, 1.93)
Education Level				Education Level			
Degree	33/3342	0.94	1.00	College or above	40/1328	2.90	1.00
Higher education	41/1656	2.48	2.62 (1.65 to 4.16)	Some college	91/1454	6.18	2.31 (1.13, 4.69)
A Level/NVQ3	27/1697	1.60	1.67 (1.00 to 2.79)	High school	65/1199	5.63	1.60 (0.73, 3.53)
O Level/NVQ2	43/2184	1.97	2.02 (1.28 to 3.19)	9 th to 11 th grade	39/760	5.26	1.00 (0.43, 2.34)
CSE/NVQ1	12/645	1.85	2.16 (1.11 to 4.18)	< 9 th grade	14/478	2.92	1.06 (0.25, 4.40)
No qualifications	52/2589	2.48	2.57 (1.64 to 4.02)	–	–	–	–
Not disclosed	1/48	2.26	2.89 (0.39 to 21.5)	–	–	–	–

^a AOR Age-adjusted Odds Ratio; CI, confidence interval; n, number with morbid obesity; N, total number in category.

Table 3

Age-standardised prevalence and logistic regression model of morbid obesity in women from England and the USA by income and education category. Figures are frequencies except where indicated.

England				United States			
	n/N	Prevalence (%)	AOR ^a (95% CI)		n/N	Prevalence (%)	AOR ^a (95% CI)
Household income				Household income			
Highest (≥£52,000)	51/2538	2.01	1.00	Highest (≥\$75,000)	75/1224	5.78	1.00
£33,800 to £52,000	57/1931	2.88	1.53 (1.04 to 2.24)	\$55,000 to \$74,999	40/514	6.99	1.67 (0.85, 3.30)
£23,400 to £33,800	76/1978	3.81	2.08 (1.44 to 3.01)	\$35,000 to \$54,999	78/881	9.47	1.85 (1.03, 3.32)
£13,000 to £23,400	140/2739	5.28	3.01 (2.14 to 4.23)	\$20,000 to \$34,999	140/1024	13.87	2.75 (1.65, 4.56)
Lowest (< £13,000)	117/2500	5.11	2.92 (2.07 to 4.12)	Lowest (< \$20,000)	163/1408	12.04	1.97 (1.19, 3.25)
Not disclosed	114/3051	4.15	2.18 (1.55 to 3.07)	Not disclosed	18/358	5.03	0.79 (0.30, 2.05)
Education Level				Education Level			
Degree	84/3723	2.23	1.00	College or above	75/1355	5.34	1.00
Higher education	46/1428	3.24	1.54 (1.06 to 2.23)	Some college	206/1777	11.81	3.11 (1.83, 5.28)
A Level/NVQ3	84/2167	3.65	1.75 (1.27 to 2.41)	High school	113/1111	10.67	2.68 (1.50, 4.79)
O Level/NVQ2	140/3163	4.60	2.07 (1.55 to 2.76)	9 th to 11 th grade	77/714	10.92	2.04 (1.09, 3.80)
CSE/NVQ1	35/474	7.38	3.47 (2.30 to 5.24)	< 9 th grade	43/452	9.24	1.87 (0.93, 3.74)
No qualifications	152/3395	4.90	2.61 (1.95 to 3.48)	–	–	–	–
Not disclosed	14/387	2.76	2.26 (1.25 to 4.09)	–	–	–	–

^a AOR Age-adjusted Odds Ratio; CI, confidence interval; n, number with morbid obesity; N, total number in category.

Table 4

Logistic regression model comparing morbid obesity in highest income or education categories with all others in US and UK men and women.

		Men			Women		
		Freq (%)	AOR (95% CI)	P value	Freq (%)	AOR (95% CI)	P value
England							
Household income	≥£52,000	37/2,446 (1.5)	0.73 (0.50 to 1.06)	0.097	51/2538 (2.0)	0.42 (0.31 to 0.57)	< 0.001
	All others ^a	131/7,327 (1.8)	Ref.		390/9148 (4.3)	Ref.	
Education qualifications	Degree	33/3,342 (1.0)	0.46 (0.31 to 0.66)	< 0.001	84/3723 (2.3)	0.48 (0.37 to 0.61)	< 0.001
	All others ^a	175/8,771 (2.0)	Ref.		457/10,627 (4.3)	Ref.	
United States							
Household income	≥\$75,000	48 / 1284 (3.7)	0.52 (0.27 to 0.98)	0.045	75/1224 (6.1)	0.51 (0.33 to 0.80)	0.004
	All others	201 / 3,935 (5.1)	Ref.		439/4185 (10.5)	Ref.	
Education level	College education	40 / 1,328 (3.0)	0.56 (0.29 to 1.08)	0.084	75/1355 (5.5)	0.36 (0.22 to 0.60)	< 0.001
	All others	209 / 3,891 (5.4)	Ref.		439/4054 (10.8)	Ref.	

^a Not disclosed category removed; AOR Age-adjusted Odds Ratio; CI, confidence interval.

were less consistent, with the highest rates found at intermediate socioeconomic positions. The high prevalence of morbid obesity in the US may account for a more widespread distribution throughout the socioeconomic scale. The distribution of morbid obesity in the US is not consistent with the hypothesis that inequalities will be more apparent with the prevalence of morbid obesity is higher. However, in both the US and England, participants with the highest levels of education or income had substantially lower odds of morbid obesity compared to the rest of the population.

4.2. Comparison with previous studies

Most previous studies have evaluated socioeconomic gradients in the distribution of all obesity considered as a single condition (Devaux & Sassi, 2013; McLaren, 2007). Greater income inequality has been associated with higher obesity prevalence, with the US experiencing both high income inequality and high obesity rates (Pickett, Kelly, Brunner, Lobstein & Wilkinson, 2005). The pattern of inequality in obesity may be changing over time. A recent NHANES study showed that the prevalence of obesity, and inequalities in obesity, increased up

to the year 2000, followed by a more gradual increase in obesity prevalence that was more evenly distributed among socioeconomic groups (Pak et al., 2016). In an analysis of Scottish data, Zhu et al. (2015), found that education and income inequality in obesity reduced as obesity prevalence increased over time.

In the present study, the highest levels of household income and educational attainment were consistently associated with lower morbid obesity. This is consistent with the analysis of Siddiqi et al., which found that in the U.S., college-educated individuals showed a lower prevalence of obesity than all other groups. Consistent with Siddiqi et al. we find that there are cross-national differences in the prevalence of morbid obesity, in the shape of the socioeconomic distribution and the absolute and relative magnitude of inequalities (Siddiqi et al., 2015). Inequalities in income and education may influence health via multiple downstream mediators including, but not restricted to, lifestyle choices, diet quality and access to resources for physical activity (Benach & Muntaner, 2007; Devaux, 2013; Devaux & Sassi, 2013; Gaglioti, Petterson, Bazemore & Phillips, 2016). Educational attainment is generally expected to be associated with higher income but this effect may be modified by other characteristics including age-group,

ethnicity and gender (Braveman, Cubbin & Egerter, 2005). The health effects of socioeconomic variables may also depend on context. For example, education may sometimes play a greater role in influencing lifestyle than income, with the opposite true in other settings (El-Sayed, Scarborough & Galea, 2012). Consequently, associations may differ between countries, or between socio-demographic groups within countries.

At the individual level, the association between education and morbid obesity may be exercised through access to health-related information, the ability to interpret this in the context of awareness of risks, and capacity to regulate choices (Devaux, Sassi, Church, Cecchini & Borgonovi, 2011). Low income may be associated with reduced access to a broad range of health resources contributing to consistent associations of income inequality with a range of health outcomes in England and the US (Martinson, 2012). Morbid obesity rates were sometimes lower at the lowest income levels which might be associated with food insecurity (Franklin, Jones, Love, Puckett, Macklin & White-Means, 2012) or high rates of occupational physical activity in this group (Bonauto, Lu & Fan, 2014).

4.3. Limitations

This study drew on national survey data from England and the United States, employing carefully standardised measurement techniques. However, cross-national comparisons may encounter differences in approach and data definitions. In this study, we compared available measures of educational level and household income, but definitions were not standardised across countries. Mapping education categories to international standards suggested that measures from the two surveys were broadly comparable but there was limited differentiation among the more central categories by international standards.

We evaluated total household income without consideration of household size. This may have biased estimates for larger households or if the respondent was not the main earner. However, our approach is generally consistent with the one used in other studies (Kakinami, Gauvin, Barnett & Paradis; Martinson, 2012). Alternatives to household income may have included the ratio of family income to poverty in NHANES and equivalised income in HSE, but consistent definitions were not available in either survey. Sensitivity analyses demonstrated that the conclusions were not altered by varying the definition of household income.

We used income data from different survey years without adjusting for purchasing power. Neither survey incorporated a measure of 'wealth', a potentially more revealing measure that may be difficult to obtain (Galobardes, Lynch & Smith, 2007). The data were cross-sectional and we are not able to evaluate causal pathways; we have focused on the effects of socioeconomic status on obesity rather than the effect of obesity on social mobility. In cross-sectional analyses, it may be difficult to distinguish between covariates that contribute confounding and those that contribute to causal relationships. Longitudinal analyses are required to increase understanding of the determinants of more extreme forms of obesity.

5. Conclusions

In the UK, both men and women with lower income or education, are more likely to have morbid obesity than those in higher socioeconomic groups. Consistent socioeconomic gradients in morbid obesity are less apparent in the US, where only those with the highest levels of income and education consistently demonstrated lower morbid obesity. The higher overall prevalence of morbid obesity in the US suggests that social environmental influences impact on obesity across social strata. In the context of high overall prevalence, socioeconomic position may now have a more limited impact on the distribution of morbid obesity. This suggests that any continuing increase in morbid obesity in the UK might result in morbid obesity

spreading into higher socioeconomic categories.

Occupying the highest socioeconomic positions appeared to offer protection against the development of morbid obesity in both England and the US. This is consistent with known graded association between socioeconomic status and health, and reinforces the importance of social factors in determining health (Commission on Social Determinants of Health, 2008). A more explicit understanding of how high socioeconomic position confers protection against morbid obesity may offer insights that might inform policies and interventions for prevention and treatment. Further work should focus on ensuring obesity interventions are accessible and effective across all social strata, and investigating whether the health consequences and costs in people with morbid obesity are socially patterned.

Competing interests

The authors declare no conflict of interest.

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Contributorship

HB conducted the analyses, contributed to interpretation of the results and wrote the manuscript. JC conducted the analyses, contributed to interpretation of the results and writing of the manuscript. MG devised the study and contributed to the analyses, interpretation of the results and writing of the manuscript.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.ssmph.2016.12.012](https://doi.org/10.1016/j.ssmph.2016.12.012).

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